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Description

COMPARTMENT SEAL

Cross Reference to Related Applications

[0001] This application is a continuation-in-part of prior Application No. 10/119,569, filed April 10, 2002, in the name of Matczak et al. and entitled "Compartment Seal".

Background of Invention

[0002] This invention relates generally to seals. More specifically, this invention relates to a compartment seal for use primarily with automotive hoses and tubes extending between two compartments.

[0003] Compartment seals are known in the prior art. Such compartment seals comprise an aperture formed within a wall separating two compartments having a grommet circumferentially lining the aperture and sized to sealably engage the periphery of a hose or tube axially disposed within the grommet to provide a seal between the compartments while having the tube or hose extend in each compartment. Typically, one of the compartments is the engine

compartment separated from an occupant compartment by a firewall or dash. It is necessary to prevent fumes and smoke produced in the engine compartment from passing through the firewall into the occupant compartment. Unless effectively sealed, smoke and fumes from the engine compartment invariably migrate into the occupant compartment. A hose or tube passing through the firewall providing fuel or oil to and from the engine compartment poses a threat for such undesirable gases to pass through into the occupant compartment via apertures providing access to both compartments.

[0004] The prior art uses a grommet configured to fit within the aperture formed in the firewall and sized to engage an outer periphery of the fuel or oil hose. However, the fuel and oil hoses have fittings at either end to engage complimentary fittings for coupling the hoses. The opening of the grommet is smaller in diameter than the fittings that are at either end of the hose. The partial resiliency of the grommet material provides limited expansion to allow passage of a fitting through the aperture in the grommet without causing undue stress and wear in an attempt to remove a fuel or oil line having a fitting. Furthermore, passing the larger fittings through the grommet causes

undue stress and wear. On the other hand, it is not feasible to pass the hose through the grommet absent the installed fittings because special tooling is needed to remove and reinstall the fittings. The present grommet design may be chamfered at the opening to facilitate and direct the hose to the centerline during assembly. However, this present grommet design is not suitable for off center positioning of the hose, which causes undue stress on both the hose and grommet. Furthermore, during more extreme angular displacements fumes and smoke leaks from the engine compartment out between the grommet and the hose extending into the occupant compartment. Such extreme angular displacements are commonly encountered with automobiles used for racing because of the limited room in both compartments as well as because of the extreme conditions these automobiles are used.

[0005] In addition, the prior art also uses caulking material, such as silicone or RTV, for example, to seal between an exterior hose or tubing and a compartment in which the hose or tubing passes through. In particular, when a "velocity stack" or "air hone" extends from a carburetor or fuel injector into an air box, the interface between an exterior of the air horn and air box into which it extends must be

sealed to prevent contaminants from entering through the interface therebetween. A velocity stack or air horn is one way to increase air flow to a carburetor or fuel injector of an internal combustion engine A velocity stack or air horn is a generally cone-shaped tube device that is open to ambient air and directs airflow to the air-fuel system. These devices are more commonly used on engines that are intended for extra power including automobile, motorcycle or power boat engines, especially in racing. In such an instance, silicon or a room-temperature vulcanizing (RTV) silicone rubber is used to seal the interface and needs time to set up before creating such a seal. Furthermore, such a seal must be broken in order to remove the air horn from the air box. Reworkability of this interface is especially problematic in racing when reduced time and effort is desirable.

[0006] Despite the activity in the prior art in attempt to form a seal within a compartment or between two compartments to eliminate fumes, smoke, and other debris from migrating through a compartment interface, a need remains for simple and inexpensive means by which a compartment of a vehicle can be effectively sealed against the entry of fumes, smoke, and other debris from outside the com-

partment when a hose or tubing extends into the compartment from outside thereof.

[0007] There is also a need to provide simple and inexpensive seal components which may readily be employed with tubing or wiring with associated fittings, and that for diverse other applications, to afford such protection in a highly convenient manner, which components may in addition afford greatly improved isolation from smoke, fumes, and other environmental elements and debris.

SUMMARY OF INVENTION

[0008] The above discussed and other drawbacks and deficiencies of the prior art are overcome or alleviated by the compartment seal of the present disclosure. In accordance with an exemplary embodiment a compartment seal comprises a body member having an opening therethrough and a plurality of openings circumferentially arranged around the opening. The body member has a periphery sized larger than an aperture in a wall and the plurality of openings providing a means for attaching the body member to the wall. A seal element secured to the body member and is configured to have an aperture therethrough. The aperture in the seal element is in general alignment with the opening in the body member. The aperture in the

seal element has a diameter less than a diameter of the opening in the body member for sealingly engaging tubing passing through the aperture in the seal element. The seal element includes a generally conically shaped portion about the aperture, wherein the generally conical shaped portion is defined at one end thereof with at least one convolute defined by a perimeter smaller than the opening and larger than a largest diameter defining the conically shaped portion, or an annular portion configured to slidably and sealably engage an air horn therethrough.

[0009] In contrast to the prior art, smoke, fumes, or other debris generated in the engine compartment are prevented from leaking through the seal element even during extreme angular displacements of the tubing extending through the seal element, such as encountered with automobiles used for racing, generally circle or oval track racing, during cornering. This is due to the use of a resilient seal and the seal having a central opening that is at least about ten percent smaller in diameter than that of the tubular structure passing therethrough.

[0010] In another embodiment, a method for a compartment seal having a variably sized aperture is disclosed. The method comprises configuring a body member having an opening

therethrough and having a plurality of openings circumferentially arranged around the opening, the body member having a periphery sized larger than an aperture in a wall and the plurality of openings providing a means for attaching the body member to the wall. A seal element is configured to have an aperture therethrough being in general alignment with the opening in the body member, the seal element including a generally conically shaped portion defined at one end having at least one convolute defined by a perimeter smaller than the opening and larger than a largest diameter defining the conically shaped portion. The seal element is secured to the body member, and the seal element is cut to form the aperture in said seal element having a diameter less than a diameter of the opening in the body member for sealingly engaging tubing passing through the aperture in the seal element.

[0011] Accordingly, the prior art problem of smoke, fumes, and other debris leaking from the engine compartment into the occupant compartment during more sever angular displacements of the tubing, such as encountered with automobiles used for racing, generally circle or oval track racing, during cornering, is avoided, while allowing such

tubing to pass through and be reworkable. The aforementioned prior art seal is not suitable for sufficiently resolving this prior art problem.

[0012] The above discussed and other features and advantages of the present invention will be appreciated and understood by those skilled in the art from the following detailed description and drawings.

Brief Description of Drawings

[0013] Referring now to the drawings wherein like elements are numbered alike in the several FIGURES:

[0014] FIG. 1 is a perspective view of a compartment seal disposed in a firewall of a vehicle;

[0015] FIG.2 is a side view of the compartment seal of FIG. 1 with a hose, partially shown, extending therethrough;

[0016] FIG. 3 is a first end view of the compartment seal of FIG. 1;

[0017] FIG. 4 is a partial view of the compartment seal taken along the line 3-3 in FIG. 3;

[0018] FIG. 5 is a partial view of an alternative exemplary embodiment of a seal element for the compartment seal of FIG. 4;

[0019] FIG. 6 is a perspective view of a pair of air horns extending into an air box and sealed therewith another alterna-

tive exemplary embodiment of a compartment seal;

[0020] FIG. 7 is a top plan view of a body member for the compartment seal of FIG. 6; and

[0021] FIG. 8. is a partial cross section of the compartment seal for one of the air horns of FIG. 6.

Detailed Description

[0022] Referring to FIGS. 1-4, a compartment seal in accordance with one embodiment is shown generally at 42. Compartment seal 42 comprises a rigid annular body member 44 having four apertures 46 circumferentially thereabout. Each aperture 46 is preferably spaced equidistant from one another to provide a manner in which seal 42 may be mounted to an automotive firewall 48 separating an engine compartment 50 from an occupant compartment 52. Body member 44 is mounted over an opening 53 (FIG. 2) configured in firewall 48. A diameter 54 of body member 44 is preferably larger than a diameter of the opening 53 configured in firewall 48 for attaching body member 44 to firewall 48 via apertures 46 and fasteners 56 (See FIG. 2). Fasteners 56 include bolts, rivets and the like. Body member 44 is preferably comprised of metal, and more preferably aluminum. An automotive hose or tubing 60 passes through an opening 66 (See FIG. 3) in body member 44.

Hose 60 may be an oil or fuel line providing fluid communication to an engine component in engine compartment 50. Hose 60 includes a fitting 62 for coupling with a component to provide the fluid communication. Fitting 62 includes flats 64 for engaging with a wrench or pliers to securely engage fitting 62 to another hose or corresponding component. It will be appreciated by one skilled in the pertinent art that an outside diameter of flats 64 is larger than an outside diameter of hose 60, but smaller than opening 66 formed in body member 44.

[0023] A seal element 72 is secured within opening 66 of body member 44 by attaching seal element 72 to a first surface 74 and a second surface 76 of a body member 44 secured to surfaces 74, 76, for example, by bonding or other known means (e.g., adhesive bonding, chemical bonding or mechanical means of attachment). In a preferred embodiment shown in FIG. 3, body member 44 includes apertures 78 circumferentially disposed proximate opening 66 for allowing seal element to be injection molded to body member 44. In this manner, when seal element 72 is injection molded, seal element material flows through each aperture 78 connecting portions of seal element 72 depending from first and second surfaces 74, 76 of body

member 44, thus providing axial and rotational retention of seal element 72 relative to body member 44. Seal element 72 is preferably comprised of a polymer such as nitrile or neoprene as well as plastics or other suitable sealing materials (e.g., rubber, preferably a fire retardant rubber).

[0024] Seal element 72 is defined from an outer circumferential edge 84 extending to define a first flat portion 85 disposed on either side of body member 44 by U-shaped portion 86. An interior portion 88 of U-shaped portion 86 attaches to first and second surfaces 74, 76 of body member 44 while an apex 90 of U-shaped portion 86 engages an edge 92 defining opening 66 of body member 44.

[0025] Referring to FIGS. 3 and 4, a first side 94 of seal element 72 extends from U-shaped portion 86 on first side 94 forming a V-portion 100 followed by a second flat portion 110. V-portion 100 is defined by a first edge 102 of a first inclined portion 103 and a second edge 104 of a second opposing inclined portion 105 forming complementary angles of about 30 degrees relative to edge 92 or about 60 degrees relative to second flat portion 110. First and second edges 102, 104 are joined via an intermediary flat

portion 106 that is substantially parallel with legs 108 and 109 forming U-shaped portion 86. Second flat portion 110 is followed by a third inclined portion 112 that extends to a third flat portion 114 that is substantially parallel to second and intermediary flat portions 110, 106. Third inclined portion 112 forms a 30 degree angle relative to second and third flat portions 110, 114 joining the same. Third flat portion 114 terminates in a central opening (or aperture) 116. Opening 116 formed by termination of flat portion 114 is smaller in diameter than a hose or tube passing therethrough by about thirty-five percent. It will be appreciated that the contacting portion of the seal (i.e., portion 114) is substantially thinner than the contacting portion of the aforementioned prior art grommet seal, whereby translational and rotational friction between the hose/tube and the seal are significantly reduced. Heretofore it was believed that a thicker and thereby harder seal would provide a better seal. However, when pressure is applied to one side of the prior art grommet the opposing side does not follow due to the thickness and rigidity of such grommets, in addition to preventing passage of installed fittings 62. The seals of the present invention do not suffer from this problem, since the op-

posing side of the seal is not required to follow the side of the seal under force in order to maintain the seal.

[0026] Still referring to FIGS. 3 and 4, an opposite side 120 of side 94 of seal element 72 will be described. Leg 109 of U-shaped portion 86 extends to a second V-portion 121. Second V-portion is defined by a first edge 122 and a second edge 124 joining first and second opposing inclined portions 103 and 105 forming complementary angles of about 45 degrees relative to edges 84, 92 and relative to second flat portion 110. Second V-portion 121 forms a V-channel that is less deep than V-portion 100. The vertex of each V-portion 100, 121 is offset from one another as shown in FIG. 4 and reside on side 120 of seal element 72. It will be noted that seal element 72 is thinnest proximate the vertex formed by joining edges 122 and 124 along a length defining seal element 72. Second edge 124 is followed by an edge 134 that is opposite edge 104 defining second opposing inclined portion 105. Edge 134 extends from second edge 124 and meets with flat portion 110 at an angle of about 40 degrees relative to edges 84, 92 or about 50 degrees relative to second flat portion 110. As edge 134 extends from second edge 124, seal element thickens until meeting with flat

portion 110. From flat portion 110 to an end of portion 114 defining opening 116, the thickness of seal element 72 remains substantially the same.

[0027] Referring to FIG. 1, seal element 72 provides for a significant amount of angular displacement of a hose 60 from the center line without loss of the seal established between the seal element 72 and the hose 60, whereby smoke and fumes are prevented from escaping therethrough. Such extreme angular displacements are commonly encountered with automobiles used for racing where available space is limited and where hoses are generally subjected to vibration and centrifugal forces during cornering that is common at racing speeds.

[0028] The sealing element will usually be fabricated by molding the first flat portion 85 directly upon an edge 92 of the metal body 44, which will advantageously constitute, or provide, a circumferential flange portion of an interior portion of a washer. To ensure a tight and strong bond with the elastomeric material forming seal element 72, the edge 92 and surfaces 74, 76 proximate edge 92 of the washer or body member 44 will desirably be roughened. In the especially preferred embodiments, moreover, the edge 92 and proximate surfaces 74, 76 will carry an agent

to increase adhesion, the choice of which will depend upon the composition of the material used to produce the first flat portion 85 itself.

[0029] It will be appreciated that the components of which the assembly of the invention is comprised will normally be made of metal (e.g., steel, aluminum, brass, etc.), except of course for the sealing element. As to the latter, any suitable natural rubber or synthetic polymer may be employed; neoprene rubber, polyurethanes, styrene/butadiene rubbers, nitrile elastomers, and silicone resins might be mentioned as typical, but the selection of a suitable material for any given application will be evident to those skilled in the art. In addition to providing the requisite flexibility, resiliency and durability under the variety of conditions to which the compartment seal might be exposed, the material from which the sealing element is formed must be capable of producing a rubber-tearing bond with the metal element. As indicated above, that may be promoted by the use of an adhesive, a bonding agent, a chemical surface activator, or the like (the choice of which will also be evident to those skilled in the art), as well as by roughening of the surface of the component to which the rubber is to be bonded (e.g., by sand-blasting

or the equivalent), or by other means. Normally, the sealing component will be integrally formed by molding of the elastomeric material directly to the metal piece, as by a compression, injection or transfer molding technique; bonding of preformed, separate seal elements may however also be feasible. Furthermore, it will be understood that although the body member 44 and seal element 72 attached to the body member have been illustrated and discussed in a circular configuration, any configuration is contemplated for the body member and seal element attached to the body member as long as the configuration is suitable to cover an opening of a wall and suitable for attaching to the wall.

[0030] Thus, it can be seen that the present invention provides simple and inexpensive means by which tubing extending between compartments can be effectively sealed against the entry of foreign matter, such as smoke and fumes. It also provides simple and inexpensive sealing components that are suitable for use in a vehicle firewall or dash assembly, to afford such protection in a convenient and highly effective manner.

[0031] Advantages obtainable by employment of the system embodying the invention are numerous. As used in an auto-

motive engine compartment or fuel and oil lines extending from the engine compartment into the driver's area, for example, they include: (1) Simpler initial installation. (2) Elimination of specialty tools to install fittings on the end of fuel and oil lines for installation or removal of such lines from the firewall. (3) Freedom to schedule installation or removal of fuel and oil lines, either individually or preferably as an entire sealed system, on a production line before or after the device or devices being operated by the system are installed in place. (4) Time saving when repairs must be made to the fuel and oil line components or the lines themselves. The lines are easily removed with coupling fittings installed without having to disconnect such fittings first and later reinstall the same using expensive tooling when working with components connected to such oil and fuel lines or the lines themselves. In the system of this application, for example, the fuel line from a rear mounted gas tank may be quickly and easily removed by disconnecting it from the rear tank, releasing its mounting means, whether a clip or other means, and drawing it easily through the seal mounted to the firewall and into the engine compartment where it may be readily disconnected, repaired or replaced and reinstalled. (5) It per-

forms more efficiently than other, more complicated seals without the complexity and losses of time, materials and effort of prior designs.

[0032] Similar advantages are present when the system embodying the invention is used with a wiring harness or other electrical wires passing through a firewall or between different compartments in general.

[0033] For example, referring now to Figure 5, an alternative exemplary embodiment of seal element 72 of Figure 4 is illustrated with body member 44 generally at 172. Seal element 172 is secured within opening 66 of body member 44 by attaching seal element 172 to a first surface 74 and a second surface 76 of a body member 44 secured to surfaces 74, 76, for example, by bonding or other known means (e.g., adhesive bonding, chemical bonding or mechanical means of attachment). In a preferred embodiment shown in FIG. 5, body member 44 includes apertures 78 circumferentially disposed proximate opening 66 for allowing seal element to be injection molded to body member 44. In this manner, when seal element 172 is injection molded, seal element material flows through each aperture 78 connecting portions of seal element 172 depending from first and second surfaces 74, 76 of body

member 44, thus providing axial and rotational retention of seal element 172 relative to body member 44. Seal element 172 is preferably comprised of a polymer such as nitrile or neoprene as well as plastics or other suitable sealing materials (e.g., rubber, preferably a fire retardant rubber).

[0034] Seal element 172, like seal element 72 in Figure 4, is defined from an outer circumferential edge 184 extending to define a first flat portion 185 disposed on either side of body member 44 by U-shaped portion 186. An interior portion 188 of U-shaped portion 186 attaches to first and second surfaces 74, 76 of body member 44 while an apex 190 of U-shaped portion 186 engages an edge 92 defining opening 66 of body member 44.

[0035] Seal element 172 includes a first convolute 200 that extends to a second convolute 202 that in turn extends to a conical member 204 as seal element 172 extends radially inwardly to a centerline 208 coinciding with an axis defining seal element 172. Seal element 172 extends further out of a plane defining body member 44 as seal element extends toward centerline 208. More specifically, first convolute 200 is defined by a U-shaped member having a first leg 210 and a second leg 212, where first leg 210

extends from a first section 214 that extends from U-shaped portion 186 substantially parallel to axis 208. Second leg 212 extends substantially parallel to axis 208 toward body member 44 and then forms a U-shaped bend 216 to form second convolute 202.

[0036] Second convolute 202 is defined by a U-shaped member having a third leg 220 and a fourth leg 222, where third leg 220 extends from a bend 216 substantially parallel to axis 208. Fourth leg 222 extends substantially parallel to axis 208 toward body member 44 and then forms a partial U-shaped bend 226 to form conical member 204.

[0037] Seal element 172 and body member 44 resemble a "witches hat" or a cone surrounded by a pair of concentric convolutes where outer convolute 200 is operably coupled to body member 44.

[0038] Seal element 172 is configured to be cut along a plane 230 substantially parallel with a plane defining body member 44 with a knife, scissors or other cutting apparatus to form an aperture through seal element 172 that is about ten percent smaller in diameter than a diameter of a wire or tube to be disposed therethrough. Plane 230 may be a plane through first, second, third , and fourth legs 210, 212, 220, and 222, respectively, as well as conical

member 204, depending on the desired diameter of a resulting aperture therethrough. For larger diameters, cuts through first or second legs 210, 212 would result in larger diameter apertures than cuts through fourth leg 222, or along a length defining conical member 204. It will be recognized by one skilled in the pertinent art that a cut along a length of conical member 204 provides a finer selection for smaller diameter apertures, as opposed to cutting either first or second convolutes 200 and 202.

[0039] In addition, legs 210, 212, 220, and 220 may include demarcations indicative of where to cut for a desired diameter. It will also be recognized by one skilled in the art that determining which corresponding pairs of legs 210, 212, 220, and 220 to cut through depends on from what direction debris may enter. Furthermore, when it is desired that either of legs 212 or 222 be cut, conical member 204 should be pulled to expose legs 212, 222 for cutting therethrough without cutting through legs 210, 220, respectively.

[0040] The compartment seals 42, 142 disclosed and claimed provides for greater flexibility of tubing and wiring extending between compartments in minimum space, and the ability to maintain a sealed system without the need to

remove and reinstall corresponding fittings on the ends of the tubing or electrical connectors on the ends of electrical wires, and the like.

[0041] Referring now to FIG. 6, another alternative embodiment of the compartment seal of FIGS. 1-4 is illustrated generally at 242. FIG. 6 illustrates a pair of air horns 250 extending through a seal element 272 extending from a body member 244. Body member 244 is configured for mounting to an air box shown in phantom generally at 252, thus sealing against contaminants entering through an interface between the air box and air horns. Each air horn 250 is defined with one end 254 configured to be operably coupled to a fuel injector or carburetor (not shown) and an opposite end 256 having a flared opening in air box 250. Although compartment seal 242 is shown and described with respect to two separable air horns 250, it will be recognized that compartment seal 242, along with compartment seals 42, 142, described above, are optionally configured for single, double, triple, or more air horns 250 or other tubular structure extending therethrough creating a sealed interface therebetween.

[0042] Compartment seal 242 comprises a rigid oval body member 244 having eight apertures 246 circumferentially

thereabout. However, it will be recognized that body member 244 may have other geometric shapes including circular or triangular, for example, depending on the number of air horns 250 extending therethrough. Each aperture 246 is preferably spaced equidistant from one another to provide a manner in which seal 242 may be mounted to an automotive air box 252 separating an engine compartment 50 from air box 252. Body member 244 is mounted over an opening (not shown) configured in air box 252. A perimeter of body member 244 is preferably larger than a perimeter defining the opening configured in air box 252 for attaching body member 244 thereto via apertures 246 and corresponding fasteners 56 (See FIG. 2). Fasteners 56 include bolts, rivets and the like. Body member 244 is preferably comprised of metal, and more preferably aluminum, such as 0.04 thick 6061-T6 aluminum.

[0043] Referring now to FIGS. 6-8, seal element 272 is secured within opening 266 of body member 244 by attaching seal element 272 to a first surface 274 and a second surface 276 of a body member 244 secured to surfaces 274, 276, for example, by bonding or other known means (e.g., adhesive bonding, chemical bonding or mechanical means of

attachment). In a preferred embodiment shown in FIG. 7, body member 244 includes apertures 278 circumferentially disposed proximate opening 266 for allowing seal element 272 to be injection molded to body member 244. In this manner, when seal element 272 is injection molded, seal element material flows through each aperture 278 (e.g., eighteen shown) connecting portions of seal element 272 depending from first and second surfaces 274, 276 of body member 244, thus providing axial and rotational retention of seal element 272 relative to body member 244. Seal element 272 is preferably comprised of a polymer such as nitrile or neoprene as well as plastics or other suitable sealing materials (e.g., rubber, preferably a fire retardant rubber).

[0044] Seal element 272, like seal element 72 in Figure 4 and seal element 172 in FIG. 5, is defined from an outer circumferential edge 284 extending to define a first flat portion 285 disposed on either side of body member 244 by U-shaped portion 286. An interior portion 288 of U-shaped portion 286 attaches to first and second surfaces 274, 276 of body member 244 while an apex 290 of U-shaped portion 286 engages an edge 292 defining opening 266 of body member 244.

[0045] Seal element 272 includes two frustoconical members 304 as seal element 272 extends radially inwardly to a corresponding centerline 308 (see FIG. 7). Seal element 272 extends further out of a plane defining body member 244 as seal element 272 extends toward a corresponding centerline 208.

[0046] Each frustoconical member 304 extends to a substantially annular portion 310 of seal element 272 that is configured to be slidably and sealably engageable with a corresponding one end 254 of a corresponding air horn 250. Annular portion 310 includes a groove 312 configured in an exterior surface 314 thereof while an interior surface 316 defining portion 310 is chamfered generally shown at 318 to facilitate slidable engagement of a respective air horn 250. Groove 312 is configured to retain a zip tie or hose clamp therein for securing seal element 272 to air horn 250.

[0047] Each frustoconical member 304 includes an inner surface 320 and an exterior surface 322. Inner surface 320 extends from aperture 266 to annular portion 310 at an angle of about 42 degrees relative to centerline 308. Exterior surface 322 extends from aperture 266 to annular portion 310 at an angle of about 45 degrees relative to centerline

308. Thus, each frustoconical member 304 tapers in thickness becoming thinner as each extends from aperture 266 toward annular portion 310.

[0048] While preferred embodiments have been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustrations and not limitation.